

ANNUAL REPORT FOR GRANT TO  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
THE CONTINUATION OF  
MEASUREMENT OF HO<sub>2</sub> AND OTHER TRACE GASES IN THE STRATOSPHERE  
USING A HIGH RESOLUTION FAR-INFRARED SPECTROMETER

NASA GRANT NAG5-9361

Annual Report No. 2

For the period 1 April 2001 through 31 December 2001

Principal Investigators: Wes Traub and Kelly Chance

January 2002

Smithsonian Institution  
Astrophysical Observatory  
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory  
is a member of the  
Harvard-Smithsonian Center for Astrophysics



## **Annual Report, No 2**

### **NASA Grant NAG5-9361**

#### **Measurement of HO<sub>2</sub> and Other Trace Gases in the Stratosphere Using a High Resolution Far-Infrared Spectrometer**

##### **1. Personnel Working Under this Grant During this Reporting Period**

Dr. Wesley A. Traub (Principal Investigator)

Dr. Kelly V. Chance (Principal Investigator)

Dr. Kenneth W. Jucks (Co-Investigator)

Dr. David G. Johnson (Co-Investigator)

##### **2. Status Summary**

This report covers the time period 1 April 2001 to 31 December 2001. During this period we continued analyzing data from past flights, exploring issues such as radical partitioning, stratospheric transport, and molecular spectroscopy and further developed our beamsplitter technology.

##### **3. Instrument and Software Development**

We have continued our work on developing beam splitters for FIRS-2 and other far infrared spectrometers. Physically, the beamsplitter is quite simple; it comprises a thin (3.5 micron) polypropylene substrate coated with an even thinner layer (1.0 micron) of germanium. Optically, these materials are a nearly ideal combination, having the right mix of real index of refraction to generate a nearly 50-50 split of the incident beam intensity, and essentially zero imaginary part of the index, giving very little absorption. The only trick is to actually fabricate the device, which we are now doing with increasing success.

Our design will give nearly 100% efficiency over the entire wavelength range of the FIRS-2 spectrometer (120 to 7 microns). This will be a significant improvement over our past beam splitter designs which use Mylar instead of Polypropylene as the substrate. Polypropylene offers significantly better optical properties but has less ideal physical properties for the deposition of Ge. In particular, the Ge does not adhere well, and in the heat of the evaporation chamber we find that the polypropylene melts at a lower temperature than Mylar. We have now successfully made Ge/polypropylene beamsplitters with reasonable optical surface quality. We are now working on methods for a more consistent and even surface quality and ensuring the ability to flatten the beam splitter for improved optical alignment.

This beam splitter work is exactly the kind of technology needed for other types of broad band far-infrared spectrometers as well. We are now applying this work to the newly funded IIP project called FIRST out of NASA Langley. We will be developing this beam

splitter for the demonstration FIRST interferometer and are part of the instrument development team.

#### **4. Data Interpretation**

We have completed the editing of a manuscript on the validation of ILAS v5.2 data with FIRS-2 profiles from our 30 April 1997 balloon flight from Fairbanks. The paper is now accepted for publication in the ILAS validation special edition of JGR [Jucks *et al.*, 2002]. We have also continued to contribute to numerous manuscripts written by our Japanese colleagues on the validation of individual molecule concentration profiles, including  $\text{H}_2\text{O}$ ,  $\text{O}_3$ , and  $\text{N}_2\text{O}$ . Some of these manuscripts are submitted for a JGR-Atmospheres special section on ILAS validation while others are still in preparation. One of us (D. Johnson) has been selected for membership on the ILAS-II science team by the Environment Agency of Japan on the basis of our proposal, "High-latitude balloon flights of the FIRS-2 spectrometer for ILAS-II validation" and is continuing contact about plans for ILAS-II validation.

Our past observations of a large discrepancy between measured and modeled  $\text{H}_2\text{O}_2$  helped to spark a study of the reaction rate of  $\text{HO}_2 + \text{HO}_2$ . The new temperature dependent constant results in much slower rates at colder temperatures, the temperatures where most of the discrepancies occur. This study resulted in a GRL paper which has a section where we show how the newly measured rate improves the comparison between measurements and modeled concentrations of  $\text{H}_2\text{O}_2$  [Christensen *et al.*, 2002], especially in the lower and middle stratosphere. We are now working to submit a second manuscript which gets into more detail about how well the models are calculating  $\text{HO}_2$  and  $\text{OH}$  and how this affects the calculated  $\text{H}_2\text{O}_2$  with the new reaction rate. Some discrepancies still exist even with this new reaction rate. This will be explored in the paper being prepared.

#### **5. Molecular Spectroscopy for Atmospheric Sensing Workshop**

One of us (K. Jucks) was one of the organizers for the NASA sponsored molecular spectroscopy workshop for atmospheric sensing in October in San Diego. The focus of this workshop was to bring together researchers in the fields of laboratory spectroscopy and atmospheric spectroscopic observations to help define the needs of the atmospheric observation community in relation to the current abilities of the laboratory spectroscopic methods. We are currently working to complete a report of the workshop that can be used as a general reference for future spectroscopic work in support of atmospheric observations.

#### **6. Future Satellite Validation**

We had expected to conduct a high-latitude campaign from Lynn Lake in summer 2002, primarily aimed at validating ILAS-II. However the launch of ILAS-II has been postponed from January 2002 to perhaps the fall. Therefore our Lynn Lake campaign has been put on hold for a year.

Instead we hope to fly FIRS-2 from Ft. Sumner in September. We wish to use this flight to establish continuity with, and improvements on past flights of FIRS-2 at mid-latitudes.

We expect that our ongoing record with the same instrumentation will prove valuable in validating future USA satellite experiments.

We have proposed, and been accepted to participate in the validation of the ACE satellite instrument of the Canadian Space Agency. The location and time of this flight will depend on available funding and the launch date of ACE.

## 5. Publications and Presentations

Christensen, I. E., M. Okumura, S. P. Sander, R. J. Salawitch, G. C. Toon, B. Sen, J.-F. Blavier, and K. W. Jucks, Kinetics of  $\text{HO}_2 + \text{HO}_2 \rightarrow \text{H}_2\text{O}_2 + \text{O}_2$ : Implications for Stratospheric  $\text{H}_2\text{O}_2$ , *Geophys. Res. Lett.*, accepted for publication, 2002.

Jucks, K. W., D. G. Johnson, W. A. Traub, K. V. Chance, J. M. Margitan, R. Stachnik, Y. Sasano, T. Yokota, H. Kanzawa, K. Shibasaki, M. Suzuki and T. Ogawa, Validation of ILAS v5.2 data with FIRS-2 balloon observations, *J. Geophys. Res.*, accepted for publication, 2002.

Kanzawa, H., T. Sugita, H. Nakajima, A. Engel, U. Schmidt, S. Aoki, T. Nakazawa, C. Camy-Peyret, S. Payan, P. Jeseck, H. Oelhaf, M. Stowasser, W.A. Traub, K. Jucks, D.G. Johnson, G.C. Toon, I. Murata, H. Fukunishi, H. Kuellmann, J.H. Park, G. Bodeker, L. Pan, T. Yokota, M. Suzuki, M. Shiotani, and Y. Sasano, Validation and data characteristics of nitrous oxide and methane profiles observed by Improved Limb Atmospheric Spectrometer (ILAS) and processed with Version 5.20 algorithm, *J. Geophys. Res.*, submitted, 2002.

Sugita, T., H. Nakajima, H. Kanzawa, T. Yokota, Y. Sasano, T. Deshler, K. Shibasaki, Y. Kondo, V. Yushkov, H. Gernandt, F. Goutail, S. Godin, J.-P. Pommereau, H. Schlager, H. Boesch, K. Pfeilsticker, C. Camy-Peyret, J.-B. Renard, M. von Koenig, H. Bremer, H. Kuellmann, I. Murata, H. Fukunishi, J. Margitan, B. Stachnik, G.C. Toon, K. Jucks, and W. Traub, Validation of ozone measurements from the Improved Limb Atmospheric Spectrometer (ILAS), *J. Geophys. Res.*, submitted, 2002.

H. Kanzawa, C. Schiller, C. Camy-Peyret, H. Oelhaf, W.A. Traub, G.C. Toon, J. Park, L. Pan, G. Bodeker, M. Shiotani, M. Suzuki, T. Sugita, H. Nakajima, T. Yokota, Y. Sasano, Validation and data characteristics of water vapor profiles observed by the Improved Limb Atmospheric Spectrometer (ILAS) and processed with Version 5.20 algorithm, *J. Geophys. Res.*, this issue, 2001a.

Johnson, D.G., Overview of spectroscopic needs for far-infrared atmospheric observations, Spectroscopy workshop, 2001.

Jucks, K.J., Spectroscopic needs of the FIRS-2 spectrometer, Spectroscopy workshop, 2001.





